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Research Article

Physiological and floral responses of mango (*Mangifera indica*) cv. Banganapalli to pre-flowering chemical treatments

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Abstract
A field experiment was conducted in a mango orchard to investigate the effects of pre-flowering chemical treatments on the physiological and yield attributes of mango cultivar Banganapalli. The research used a Randomised Complete Block Design (RCBD) with three replications. There were ten different treatments: 1% Urea + 20 ppm NAA (T_1), 1% Urea + 200 ppm Salicylic Acid (T_2), 2% Urea + 20 ppm NAA (T_3), 2% Urea + 200 ppm Salicylic Acid (T_4), 1% KNO_3 + 20 ppm NAA (T_5), 1% KNO_3 + 200 ppm Salicylic Acid (T_6), 2% KNO_3 + 20 ppm NAA (T_7), 2% KNO_3 + 200 ppm Salicylic Acid (T_8), water spray (T_9), and an untreated control (T_{10}). Among the various treatments, the application of 2% KNO_3 combined with 20 ppm NAA (T_7) resulted in the highest physiological indices, including chlorophyll index (42.61, 40.78 and 37.78 SPAD), carbohydrate accumulation (18.86, 26.85 and 24.68 mg $100g^{-1}$), leaf nitrogen assimilation (1.35, 1.75 and 1.67%), and C/N ratio (13.97, 15.34 and 14.78). Furthermore, this treatment exhibited superior flowering characteristics, such as increased total flower count per panicle (791.82), enhanced hermaphrodite flower formation (239.40), higher fruit set percentage (0.48 %), improved fruit retention (13.71), greater fruit number (129.22), and higher fruit yield per tree (50.04kg), highlighting its efficacy in promoting reproductive success and yield enhancement in mango cv. Banganapalli.

Keywords: Pre-flowering Chemicals, Mango, Physiology, Flowering, Yield

INTRODUCTION

India, the largest mango producer, faces low productivity due to poor orchard management. Key issues include excessive tree spacing, ineffective canopy management, premature fruit drop, and a lack of adoption of modern technology (Prakash *et al*., 2015; Thiruezhirselvan *et al*., 2024). Banganapalli, the earliest mango cultivar to reach markets, has recently experienced a marked decline in both production and productivity. The postponement of flowering results in subsequent delays in fruit setting, development, and harvesting (Prem *et al*., 2025). Pre-monsoon rain can adversely affect the appearance and quality of these late-developing fruits. Therefore, it is essential to create an effective solution to promote flowering at the right time from newly emerged vegetative flush (Lakshmi Devi *et al*., 2023). Smallholder mango growers face several key constraints, including limited technical knowledge, pest and disease pressures, low market returns, scarce land and water resources, and inadequate grafted seedlings (Dessalegn *et al*., 2014). Pre-harvest application of nutrients and growth regulators enhances fruit development, yield, and quality by influencing physical and biochemical changes (Patel *et al*., 2023). Growth regulators also modulate plant growth, improving flowering, fruit set, and overall fruit quality of mango (Kundu *et al*., 2024). Foliar application enables rapid nutrient uptake through leaf stomata, facilitating systemic distribution to meet the plant's needs. Exogenous application of growth regulators to panicles mitigates endogenous inhibitors, reducing abscission and enhancing yield. Previous research has demonstrated that nutrients and plant growth regulators (PGRs) have the potential to enhance fruit retention and yield (Sarkar *et al*., 2022).

Naphthalene acetic acid (NAA) is effective in inducing blooming, delaying the abscission of flower buds, flowers, and unripe fruits, as well as enhancing fruit size and improving the production and quality of various fruits (Maurya *et al*., 2020). Research conducted by Lokesh *et al*. (2020) indicates that the application of salicylic acid as a foliar spray improves the quality characteristics of mango fruit and extends its shelf life during storage. In recent years, nations that import mangoes have increasingly recognized India as a provider of exceptional-quality mangoes, owing to the country's rich diversity and plentiful supply of this fruit. The rising demand for premium-quality mangoes across local, national, and global markets has driven the development of innovative production strategies and techniques, which are vital for sustaining cultivation amid rapidly changing climatic conditions (Antwi-Boasiako *et al*., 2024). The present research aimed to investigate the impact of various chemicals on the physiology, flowering and yield characteristics of the mango cultivar Banganapalli.

MATERIALS AND METHODS

A field experiment was conducted in an eight-year-old mango orchard located in Karikili village, near Vedandhangal, Chengalpattu District, Tamil Nadu (Latitude: 12.594430, Longitude: 79.842889, Altitude: 50 m) during the 2023-2024 period. The study investigated the impact of pre-harvest chemicals on the physiological and yield characteristics of the mango cultivar Banganapalli. The trees were spaced 5 metres apart. The experiment was set up using a Randomised Complete Block Design (RCBD) and was reproduced three times. The treatments include: 1 per cent of Urea + Naphthalene Acetic Acid (NAA) 20 ppm (T_1), 1 per cent of Urea + Salicylic acid 200 ppm (T_2), 2 per cent of Urea + NAA 20 ppm (T_3), 2 per cent of Urea + Salicylic acid 200 ppm (T_4), 1 per cent of KNO_3 + NAA 20 ppm (T_5), 1 per cent of KNO_3 + Salicylic acid 200 ppm (T_6), 2 per cent of KNO_3 + NAA 20 ppm (T_7), 2 per cent of KNO_3 + Salicylic acid 200 ppm (T_8), Water Spray (T_9) and Control (T_{10}). The initial application of Urea and KNO_3 occurred at the pre-pre-flowering stage on November 20, 2023, while NAA and Salicylic acid were applied at the full bloom stage on February 15, 2024. The chemicals were applied using a rocker sprayer, ensuring uniform foliar coverage across the trees.

Total chlorophyll index

Total chlorophyll in the fresh leaves was determined as SPAD units by using Minolta chlorophyll meter (SPAD, 502). Measurements were collected from the uppermost fully expanded leaf (4th or 5th leaf from the apex) following the method of Wood *et al.* (1992). SPAD 502 readings were noted during the flowering, fruit development and harvesting stages. Consequently, forty SPAD readings were gathered from fifteen plants to determine the mean SPAD 502 values for each treatment.

Total nitrogen (%)

The Microkjeldahl method (Humphries, 1956) was used to estimate the total nitrogen content in the leaf samples after harvest. The samples were digested with concentrated sulfuric acid and a digestion mixture in a digestion chamber until a light bluish-green residue was obtained. The known aliquot was distilled in an alkaline medium, and the liberated ammonium was absorbed in a boric acid mixed indicator solution after complete distillation. The solution was then disconnected from the receiving flask, and the content was titrated against standard sulfuric acid until the colour changed from green to a wine-red colour (Piper, 1966).

C/N ratio

The carbohydrate (C) and total N content were estimated by colorimetric method of Somogyi (1952) and Micro-Kjeldahl method of Piper (1966). The C/N ratio was derived by dividing the total carbohydrate content by the total nitrogen content.

Number of flowers per panicle

The number of total flowers per panicle was obtained by taking the sum of male and hermaphrodite flowers.

Number of hermaphrodite flowers per panicle

At the time of full bloom, five panicles were randomly selected from each tree and hermaphrodite flowers were counted. Average values for these panicles were taken to represent the number of hermaphrodite flowers per panicle.

Fruit set percentage

The number of days taken from the date of panicle initiation to fruit formation of panicle at the mustard stage was recorded. Ten shoots were randomly tagged (from North, South, East and West directions) and the fruit set was recorded. The mean number of days taken for fruit set after panicle initiation was computed.

Number of fruits

The number of fruits harvested from each treated tree was counted at the time of each harvesting was summed up and the data was expressed as the number of fruits per tree.

Statistical analysis

The data underwent statistical analysis (Panse and Sukhatme, 1985) using the AGRES software. Mean comparisons were conducted after computing analysis of variance (ANOVA), standard deviation (SE(d)) and least significant difference (LSD) values, with the critical difference set at a significance level of five per cent.

RESULTS AND DISCUSSION

An effective crop management strategy must ensure the continuous functionality of plant physiological processes, as these directly influence yield performance (Prakash *et al*., 2015). In mango cultivation, sustained vegetative vigor throughout developmental stages is supported by integrated physiological mechanisms that promote efficient biomass accumulation with minimal metabolic disruption. Experimental evidence reveals that foliar application of 2% potassium nitrate (KNO_3) and 20 ppm naphthalene acetic acid (NAA) significantly elevated leaf chlorophyll index (42.61, 40.78 and 37.78) at flowering, fruit development and harvest stages respectively (Fig. 1). Potassium contributes to chlorophyll stability by inhibiting its degradation and facilitating the synthesis of photosynthetic pigments (Naciri *et al*., 2021). These findings are consistent with those of Ayaz *et al*. (2023), who reported an increase in chlorophyll content following potassium foliar supplementation. NAA also exerted a pronounced effect on chlorophyll dynamics; Parveen *et al*. (2017) observed enhanced biosynthesis and reduced degradation upon exogenous NAA application. This was further corroborated by Khandaker (2017), who documented elevated chlorophyll levels in wax apples treated with NAA. As a synthetic auxin, NAA enhances photosynthetic activity and chlorophyll synthesis, thereby promoting overall plant growth (Hu *et al*., 2022).

The present study revealed that the foliar application of 2% KNO_3 combined with 20 ppm NAA significantly increased total carbohydrate content across various growth stages (18.86, 26.85 and 24.68 mg $100g^{-1}$) (Fig. 2). This enhancement is attributed to the enzymatic activation induced by KNO_3, particularly of those involved in carbohydrate biosynthesis. Potassium's role in lowering osmotic potential helps mitigate water stress and supports carbohydrate formation (Al-Bamarny, 2010). Additionally, potassium stimulates key enzymes, such as nitrate reductase and starch synthetase, facilitating the synthesis of proteins and carbohydrates (Pilli *et al*., 2025). Consistent with these findings, NAA application also contributed to elevated carbohydrate levels, likely due to its positive effect on photosynthetic pigment concentration. Balbaa and Talaat (2007) similarly reported increased carbohydrate accumulation in peppermint leaves following NAA treatment. Furthermore, NAA enhances nutrient translocation and boosts protein and carbohydrate synthesis, as supported by Ullah *et al*. (2021).

The nitrogen content of the leaf was affected by 2 per cent potassium nitrate and 20 parts per million of NAA; however, the impact of potassium nitrate on the nitrogen content (1.35, 1.75 and 1.67 per cent) of the leaf was statistically significant (Table 1). According to Jawandha *et al* (2017) the nitrogen content in the leaves of plum was dramatically increased when foliar applications of various kinds of potassium were applied to the

Table.1. Effect of pre-flowering spray of chemicals on leaf nitrogen content (%) and C/N ratio at different stages

Treatments	Nitrogen content (%)			C/N ratio		
	Pre flowering stage	**Fruit development stage**	**Harvest stage**	**Pre flowering stage**	**Fruit development stage**	**Harvest stage**
T_1	1.15	1.57	1.31	11.23	9.72	10.86
T_2	1.20	1.43	1.38	9.64	9.95	9.09
T_3	1.27	1.61	1.33	10.80	9.83	11.17
T_4	1.09	1.49	1.46	11.16	9.95	8.87
T_5	1.26	1.70	1.42	12.15	11.05	12.15
T_6	1.20	1.64	1.51	11.96	9.97	10.15
T_7	1.35	1.75	1.67	13.97	15.34	14.78
T_8	1.21	1.73	1.60	13.88	14.08	13.84
T_9	0.95	1.40	1.36	11.53	9.73	8.85
T_{10}	0.87	1.33	1.11	10.75	9.48	10.17
SE(d)	0.08	0.11	0.09	0.76	0.69	0.73
CD (5%)	0.17	0.22	0.19	1.55	1.42	1.50

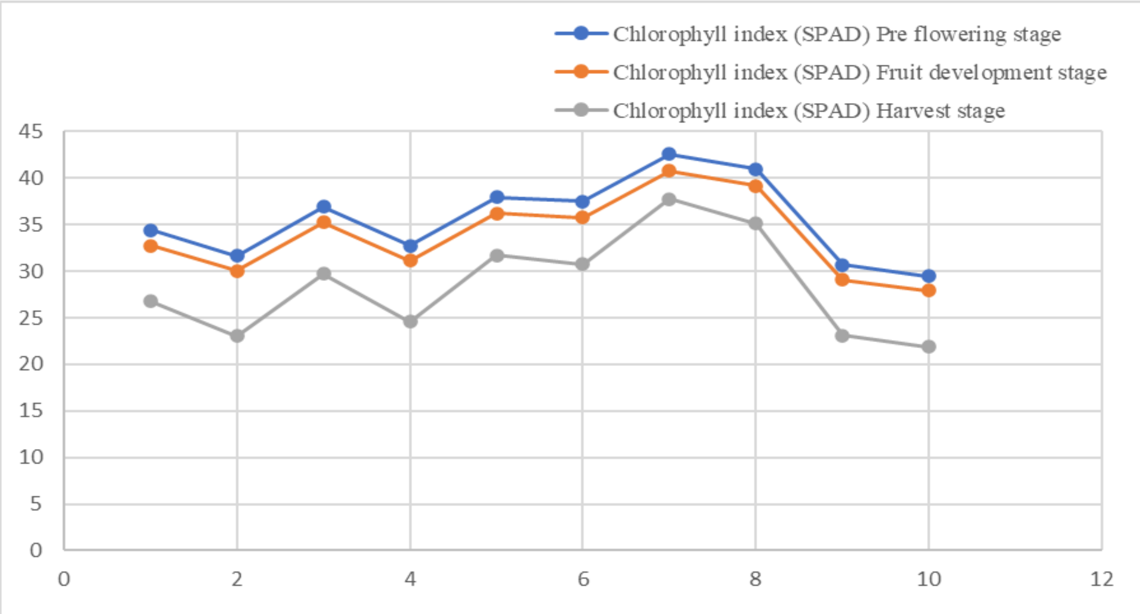

Fig.1. *Effect of pre-flowering spray of chemicals on chlorophyll index*

plants. The treatment findings showed a considerable rise in the C/N ratio that was sprayed with KNO_3 at a concentration of 2% and 20 parts per million NAA. Khattab *et al*. (2006) found similar outcomes in mango.

In the current investigation, the application of 2% potassium nitrate and 20 ppm NAA had a significant impact on the maximum number of hermaphrodite flowers per inflorescence (791.82). The results may be attributed to the presence of floral stimuli in stems when buds are induced by KNO_3, suggesting that KNO_3 may enhance bud sensitivity to floral stimuli. The aforementioned results align with the findings presented by Prasath *et al* (2024) in mango. The NAA treatment, on the other hand, shows the capacity to increase the number of hermaphrodite flowers produced by each inflorescence. The findings were in agreement with Chung *et al.* (2023), who found that NAA increased the proportion of perfect flowers to staminate flowers in mango.

In the present investigation, the combined application of potassium nitrate and 20 ppm NAA yielded the highest fruit set (0.48%) and retention rates (13.71%). This effect may be attributed to potassium's role in lowering osmotic potential, thereby alleviating water stress. Moreover, potassium is integral to carbohydrate biosynthesis. KNO_3 supplementation elevated nitrogen levels in the treated plants, thereby enhancing carbohydrate reserves and supporting reproductive development. The positive interaction of potassium nitrate with fruit physiology contributed to improved fruit quality and retention. Comparable results were reported by Verma *et al*. (2022) in Cape gooseberry.

The exogenous application of NAA in this experiment likely elevated endogenous auxin concentrations, which may have inhibited the formation of the abscission layer by suppressing the enzyme activity responsible for fruit drop. Similar observations were reported by Gattass *et al*. (2018) in mango. It is well established that declining auxin levels in fruit tissues trigger the development of abscission layers, leading to premature fruit drop and reduced retention, as documented by Anand *et al*. (2003). Furthermore, the foliar application of NAA significantly influences flower number, controls flower drop and fruit drop, and improves fruit retention per shoot, as well as fruit set (Badal and Tripathi, 2021).

In the present investigation, the maximum number of fruits per tree (129.22) was recorded with the application of potassium nitrate coupled with 20 ppm NAA (Table 2). Patoliya *et al.* (2017) reported that 2% KNO_3 yielded the maximum number of fruits per tree in Dashehari mango. Similar results were registered by Katwesige *et al* (2022) in mango. The necessity of potassium also increases at the time of flowering and plays a crucial role in the retention of fruit throughout various stages of fruit development (Patel *et al.*, 2018). The above demand in the shoots was being compensated through the foliar application of potassium nitrate which has positively impacted the all-over yield from the Kesar mango tree.

In the present study, potassium nitrate application significantly enhanced fruit weight in mango, likely due to improved fruit development efficiency and increased nutrient accumulation in treated trees. These findings are consistent with those of Sajid *et al*. (2022), who reported similar outcomes in mango. The observed acceleration in fruit growth and final size can be attributed to the exogenous application of auxins, which promote cell elongation and enlargement. This is further supported by the work of Naleo *et al*. (2018), whose findings

Table 2. Effect of pre-flowering spray of chemicals on flowering and yield parameters

Treatments	Total number of flowers per panicle	Hermaphrodite flowers per panicle	Percentage of fruit set	Fruit retention (%)	Number of fruits	Fruit yield per tree (kg)
T_1	737.52	185.64	0.39	12.05	85.11	30.13
T_2	726.49	174.72	0.35	11.54	81.89	27.63
T_3	741.66	189.74	0.39	12.75	87.33	31.45
T_4	732.29	180.47	0.37	11.68	83.78	29.18
T_5	754.39	202.34	0.45	13.01	113.22	41.17
T_6	748.24	196.25	0.43	12.86	92.00	33.21
T_7	791.82	239.40	0.48	13.71	129.22	50.04
T_8	764.38	212.24	0.46	13.42	123.33	45.88
T_9	710.89	159.29	0.31	10.08	60.22	20.26
T_{10}	699.27	147.77	0.31	9.35	45.33	12.48
SE(d)	23.24	12.75	0.02	0.46	6.42	2.32
CD (5%)	47.54	26.09	0.03	0.93	13.14	4.75

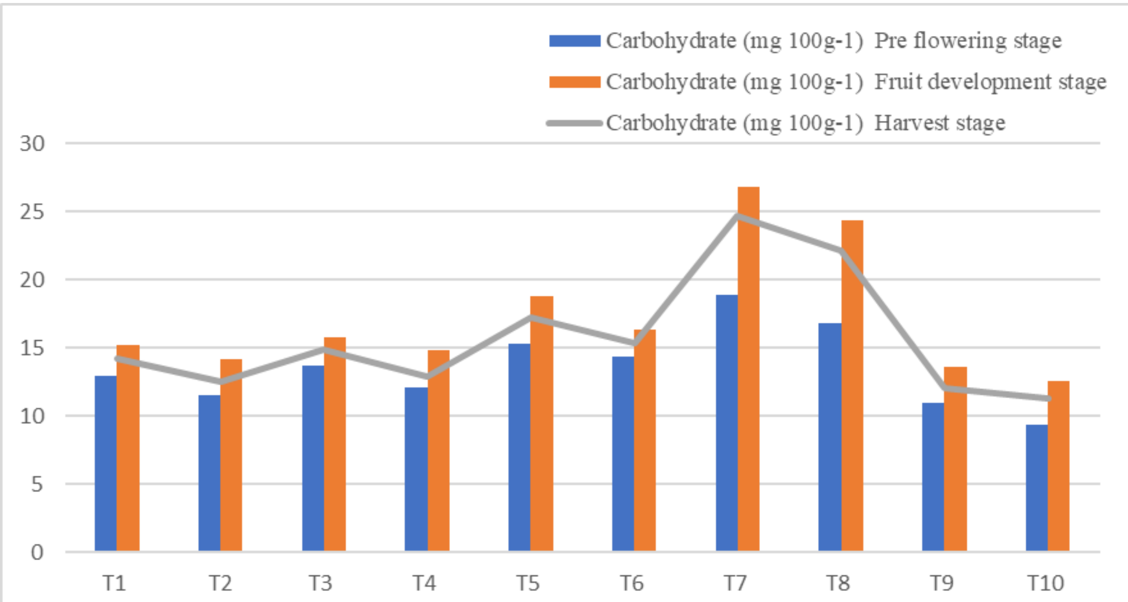

Fig.2. *Effect of pre-flowering spray of chemicals on carbohydrate content*

corroborate the positive influence of auxins on mango fruit development.

The elevated yield can be ascribed to the optimal percentage of flowering shoots, enhanced fruitset, increased fruit set per panicle, reduction of young fruit let abscission, and a greater number of fruits per tr ee, all contributing to the yield (50.04kg increase in trees treated with the aforementioned application in this present study. The observed phenomenon may be attributed to the flowering induced by KNO_3. The increase in fruit yield with KNO_3 may be attributed to a rise in fruit set and the subsequent synthesis of proteins from amino acids, for which potassium is crucial. KNO_3 application has been associated with enhanced reproductive traits, notably an increase in hermaphrodite flowers, which improves pollination efficiency and fruit set. These outcomes underscore its role as a vital foliar spray for promoting flowering, fruiting, and overall yield in mango cultivation (Shashwat *et al*., 2025).

The application of NAA significantly increased fruit yield per tree, with its effectiveness closely tied to the timing and concentration of the treatment. Exogenous NAA has been shown to enhance physiological activity, thereby improving fruit set (Yadav *et al*., 2021). Fruit yield is influenced by multiple traits modulated by NAA, particularly through its auxinic action that promotes cell division and expansion processes that contribute to larger fruit size and higher yield, as observed in Irwin mango trees (Chung *et al*., 2023). NAA also stimulates endogenous auxin production, further reinforcing its developmental impact. The highest pulp weight and pulp percentage were recorded in trees treated with potassium nitrate and 20 ppm NAA, while control plants exhibited the lowest values in the present study. The Comparable results were documented by Chouhan *et al*. (2025), who observed an increase in pulp weight with potassium foliar supplementation, highlighting potassium's crucial role in plant growth, cell expansion, water uptake, and nutrient transport, which together promote the development of well-formed, pulpy fruits.

Conclusion

In conclusion, the combined application of potassium nitrate and 20 ppm NAA significantly influenced key physiological metrics, including chlorophyll index, carbohydrate accumulation, leaf nitrogen assimilation, and the carbon-to-nitrogen ratio. These enhancements in nutrient uptake and biochemical efficiency facilitated optimal floral induction and reproductive development, thereby contributing to improved yield performance in the Banganapalli mango cultivar.

Conflict of interest

The authors declare that they have no conflict of interest.

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